

Mining Images in Publicly-Available Cameras for Homeland Security

A dramatic increase or decrease in the number of people appearing at a location can be an indicator that something has happened that may be of interest to law-enforcement, public health, or security. This work demonstrates how low quality camera images can be used to automatically alert when an unusual number of people are absent or present at a location. We report on experiments using publicly available, inexpensive cameras already operational over the Web. A "historical database" (H) for each camera is constructed by capturing images at regular time intervals and applying a face detection algorithm to store the number of faces appearing in each image ("face count"). Later, given an image X having timestamp t , if the face count of X is significantly higher or lower than the expectation inferred from H for time t , an unusual number of people are considered to be present in the image.



Figure 1. Image captured from publicly available webcam on left and with automated face detection on right.

Face Detection

Given an image, Schneiderman's face detection program [2004] reports the number of faces found by exhaustively comparing varying size models faces against all pixel positions.

Anomaly Detection

Hutwagner et al. at CDC proposed an aberration detection model for bioterrorism surveillance of hospital data [2002]. Deviations in current data are compared to an historical average. Our approach builds on this notion. In the initial phase a historical database is constructed from which averages are computed (steps 1 and 2 in Figure 3). Then, in an operational phase, a decision is made about the number of people appearing in a given image based on shifts away from the mean (step 3 in Figure 3).

CameraWatch

	7th Ave and 47th Street New York NY (video)
	45th and Broadway, Lindys Restaurant New York NY (video)
	46th & Broadway, Times Square New York NY (video)
	Broadway at the corner of 46th Street, TGI Fridays in Times Square New York NY (video)
	43rd & Broadway, Times Square One Building New York NY (video)
	46th Street and 7th Avenue, Doubletree Hotel New York NY (video)
	750 7th Avenue, Morgan Stanley Building New York NY (video)
	From Statue of Liberty, Past Pier 40, Liberty Island New York NY (video)

Figure 2. Example URLs from NYC.

In 2003, Sweeney developed automated tools that mine the World Wide Web ("Web") for web addresses (or "URLs") of on-line cameras. More than 6000 webcams showing people in public spaces in the United States were found. A sample of 200 of these URLs are available at privacy.cs.cmu.edu/dataprivacy/projects/camwatch/.

One URL was selected from CameraWatch as the subject of these experiments. The URL is www.earthcam.com/cams/newyork/timesquare/. It views Time Square (1552 Broadway at 46th Street, New York, NY 10036). Figure 4 provides an example of an image from this webcam. We did not place this camera on-line! We're just using it.

1. A "historical database" (H) for a camera is constructed by capturing images at regular time intervals throughout each day and applying a face detection algorithm to each image captured. The number of faces appearing in each image ("face count") along with a date and timestamp are stored.
2. Averages and standard deviations are computed for each time interval in H over varying classes to which the date and time stamp belongs. Date classes include current weekdays/weekend, day of week, time of month, and seasons. Holidays and events are a special class.
3. Given an image X having timestamp t_x , if the face count of X is more than 2 standard deviations above the average (or 2 standard deviations below the average) of any class to which t_x belongs, then an unusual number of people are considered to be present in the image.

Figure 3. Overall approach for detecting whether an unusual number of people are appearing in a camera image.



Figure 4. View from publicly available webcam in NYC. Ten faces were detected, and 11 were manually counted.

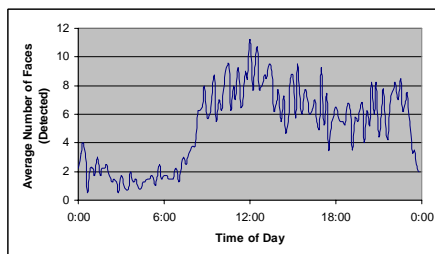


Figure 5. Average number of faces detected in webcam images (see Figure 2) during a standard weekday from one week in the winter. Noon (12:00) is the most popular time and 3am (3:00) is least popular.

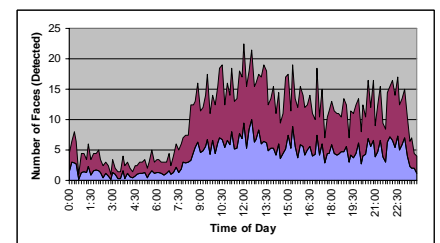


Figure 6. Range of values considered "normal" for the time of day (middle area). Values above (top) or below the middle area (bottom area) are considered "unusual."

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<http://privacy.cs.cmu.edu/dataprivacy/projects/videocount/index.html>